PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.:	10/602,458	Confirmation No.: 4512
Applicant(s):	Eric Norman Johnson	
Filed:	June 23, 2003	
Art Unit:	2121	
Examiner:	Pham, Thomas	
Title:	ADAPTIVE CONTROL SYSTEM HAVING HEDGE UNIT AND RELATED APPARATUS AND METHODS	

Docket No.: 024060/264885
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Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT
37 C.F.R. § 1.121

Sir:

In response to the non-final Office Action dated January 4, 2006, please amend the above-identified application as follows:

Amendments to the Claims begin on page 2 of this paper.

Remarks/Arguments begin on page 5 of this paper.

Amendments to the Claims: the claims as amended are stated below.

1. **(Original)** A method comprising the step of:

a) generating a hedge signal to avoid adaptation to at least one characteristic of an adaptive control system and/or a plant controlled by the adaptive control system.

2. **(Original)** A method as claimed in claim 1 further comprising the steps of:

b) modifying a commanded state signal with the hedge signal; and

c) generating a reference model state signal based on the commanded state signal modified with the hedge signal in the step (b).

3. **(Currently Amended)** A method as claimed in claim 2 further comprising the step of:

d) generating a tracking error signal based on the reference model state signal and a plant state signal; and

e) generating an adaptive control signal **based on the tracking error signal** to adapt control response of the adaptive control system.

4. **(Original)** A method as claimed in claim 1 wherein the hedge signal is generated in the step (a) based on a difference between a first signal derived from a plant model not having the characteristic, and a second signal derived from a plant model having the characteristic.

5. **(Original)** A method as claimed in claim 4 wherein the first signal is generated based on an input control signal and a plant state signal in addition to the plant model not having the characteristic, and the second signal is generated further based on a command control signal and a plant state signal in addition to the plant model having the characteristic.

6. **(Original)** A method as claimed in claim 5 wherein the input control signal is generated based on at least one of the commanded state signal, reference model state signal, a plant state signal, and an adaptive control signal.

7. **(Original)** A method as claimed in claim 6 wherein the command control signal is generated based on the input control signal modified by a control allocation and a control characteristic imposed by the controller.

8. **(Currently Amended)** A method as claimed in claim 4 [[where in]] **wherein** the second signal is generated based on an actuator state signal.

9. **(Original)** A method as claimed in claim 5 further comprising the step of:

b) generating a display based on the input control signal, an operator generating the command control signal based on the display.

10. **(Original)** A method as claimed in claim 1 wherein the plant is an aircraft and/or spacecraft.

11. **(Original)** A method as claimed in claim 1 wherein the plant is an automobile.

12. **(Original)** A method as claimed in claim 1 wherein the plan is an unmanned vehicle.

13. **(Currently Amended)** In an adaptive control system for controlling a plant, a hedge unit coupled to receive at least one control signal and a plant state signal, the hedge unit generating a hedge signal based on the control signal, the plant state signal, and a hedge model including a first model having a characteristic to which the adaptive control system is not to adapt, and a second model not having the characteristic to which the adaptive control system is not to adapt, the hedge signal used in the adaptive control system to remove **an effect of** the characteristic from a signal supplied to an adaptation law unit of the adaptive control system so that the adaptive control system does not adapt to the characteristic in controlling the plant.

14. **(Original)** An adaptive control system as claimed in claim 13 wherein the characteristic is a time delay between generation of the commanded state signal by the controller at a time, and receipt by the controller of the plant state signal resulting from the commanded state signal generated at the time.

15. **(Original)** An adaptive control system as claimed in claim 13 wherein the characteristic is a time delay between generation of a state by the plant and sensing of the state of the plant by the sensor to generate the plant state signal.

16. **(Original)** An adaptive control system as claimed in claim 13 wherein the characteristic pertains to a control limit of the actuator used to control the plant.

17. **(Original)** An adaptive control system as claimed in claim 13 wherein the control limit pertains to actuator end points.

18. **(Original)** An adaptive control system as claimed in claim 13 wherein the control limit pertains to actuator dynamics.

19. **(Original)** An adaptive control system as claimed in claim 13 wherein the control limit pertains to a rate limit of the actuator.

20. **(Original)** An adaptive control system as claimed in claim 13 wherein the control limit pertains to quantization effects associated with the actuator.

21. **(Original)** An adaptive control system as claimed in claim 13 wherein the plant is an aircraft and/or spacecraft.

22. **(Original)** An adaptive control system as claimed in claim 13 wherein the plant is an automobile.

23. **(Original)** An adaptive control system as claimed in claim 13 wherein the plant is an unmanned vehicle positioned remotely from an operator.

REMARKS

Status of Claims

This Amendment is fully responsive to the Office action dated January 4, 2006. The Examiner is thanked for his thoughtful and thorough review of the application, as indicated by the detailed Office action. The following amendments and remarks are respectfully submitted in response to the Office action.

In the Office action, Claims 1-23 were rejected under 35 U.S.C. 102(b) based on U.S. Patent No. 5,367,612 ("the Bozich patent").

By the present Amendment, Claims 3, 8, and 13 have been amended to improve their form, not for reasons of patentability. Following the Amendment, Claims 1-23 remain pending in the application. Reconsideration and withdrawal of the rejection of Claims 1-23 is requested for the following reasons.

Rejection of Claims 1-23 based on the Bozich Patent

On Page 3, Item 6 of the Office action, Claims 1-23 were rejected under 35 U.S.C. 102(b) based on the Bozich patent. The relevant legal standards, the Bozich patent, and the reasons that Claims 1-23 are patentable, are addressed sequentially below.

A. Legal Standards Regarding Anticipation under 35 U.S.C. 102

Anticipation under 35 U.S.C. §102 requires that each and every limitation of the claimed invention be disclosed in a single prior art reference. *In re Spada*, 911 F.2d 705, 708 (Fed. Cir. 1990). *See* MPEP 2131; *Verdegaal Bros. v. Union Oil Co.*, 814 F.2d 628, 631, 2 U.S.P.Q.2d 1051, 1053 (Fed. Cir. 1987). "The identical invention must be shown in as complete detail as is contained in the . . . claim." *Richardson v. Suzuki Motor Co.*, 868 F.2d 1226, 1236, 9 U.S.P.Q.2d 1913, 1920 (Fed. Cir. 1989). Furthermore, the language of 35 U.S.C. 102 stating "A person shall be entitled to a patent unless-..." has been interpreted as putting the burden on the Examiner to establish a *prima facie* case of anticipation. *In re Gene R. Wilder*, 429 F.2d 447, 450 (CCPA 1970). "Only if this burden is met does the burden of coming forward with rebuttal argument or evidence shift to the applicant." *In re Rijckaert,* 9 F.3d 1531, 1532 (Fed. Cir. 1993).

B. U.S. Patent No. 5,367,612 ("the Bozich patent")

The Bozich patent discloses an adaptive process control system selectively controlling vibrations in a given medium in real time (Abstract, Lines 1-2). Vibration sensors are used to sense vibration in the medium, and a vibration generator such as an electromagnetic shaker is used to generate offsetting vibrations applied to the medium (Abstract, Lines 8-13). A neural network controller controls the vibration generator so as to force the sensed vibration at a desired point to a given level (Abstract, Lines 13-16). The neural network controller thus adapts to the unwanted vibration in order to eliminate it (Abstract, Lines 16-17).

In Fig. 3B the Bozich patent discloses a neuro-controller 32I that receives signal A0 from a sensor S0 (Fig. 1) that senses external or internal source or forced vibrations of a medium, as well as the difference from node 37 between the signal A0 and the signal A2 output by the dynamic sensor 39 which appears to be used to detect forced and error vibrations of the medium 24 which are to be damped (Col. 6, Line 50-Col. 7, Line 41; Col. 12, Line 57 – Col. 13, Line 35). This difference "cse0" is used in the "linearization mode" to linearize the controlled dynamic device 34 (Col. 13, Lines 24-28). The inverse neuro-emulator 36I receives the signal A2 from dynamic sensor 39 and uses it together with the difference between the output of the inverse neuro-emulator 36I and the signal D0 input to the node 35, to adjust the connection weights of the inverse neuro-emulator 36I (Col. 13, Lines 7-11). When the difference generated by node 35 is zero, then the Bozich patent states that the inverse neuro-emulator 36I represents an exact imitation of the inverse transfer function of the transducer 34 and the media 24 (Col. 13, Lines 11-15). The connection weights of the inverse neuro-emulator 36I are provided to the neuro-controller 32I as indicated by line 33 (Col. 13, Lines 16-20).

The signal "cse0" is the difference between a sensed force vibration and sensed forced and error vibration and nonlinearities of the controlled dynamic device 34 which are sensed from the media 24 (Col. 13, Lines 24-27). The signal "cse0" causes the neuro-controller 32I to adapt to damp error vibration and to linearize the controlled dynamic device 34 (Col. 13, Lines 24-29). Thus, the signal "cse0" causes the neuro-controller 32I to adapt to the error vibration and nonlinearities (Col. 13, Lines 20-24).

C. Claims 1-23 Are Patentable Over the Prior Art

In contrast, Claim 1 recites "a) generating a hedge signal to avoid adaptation to at least one characteristic of an adaptive control system and/or a plant controlled by the adaptive control system." "Characteristic" is defined in the subject application as follows:

> "Characteristic" is a property of a plant or control system that has an effect for which adaptation of the control system is not to be performed. The characteristic can be a time delay between generation of a command signal and sensing and report of the plant state resulting from the command signal to the control system. The characteristic can also be a control limit such as actuator end points, e.g., extreme positions, temperatures, pressures, etc. obtainable by the actuator, actuator dynamics, rate limits, quantization effects, and possibly others. The characteristic can also be a feature of a sensor, for example, the time delay from change of a plant state to sensing of that changed plant state by the sensor. The characteristic can also be an operator's control or response.

The Bozich patent generates no signal that is used to avoid adaptation to a characteristic as defined. To the contrary, the signal "cse0" causes the neuro-controller 32I to adapt to damp error vibration and to linearize the controlled dynamic device 34. Col. 3, lines 27-42 fail to disclose the claimed invention because the adaptive vibration control system of the Bozich patent adapts to both error vibration and to linearize the controlled dynamic device 34. Accordingly, the adaptive control system of the Bozich patent does not generate any hedge signal to avoid adaptation to a characteristic as recited in Claim 1. Thus, Claim 1 is patentable over the prior art.

Claims 2-12 depend from Claim 1 and include all of the limitations of that Claim plus additional limitations that are not disclosed in the prior art. For example, Claim 2 recites "b) modifying a commanded state signal with the hedge signal; and c) generating a reference model

state signal based on the commanded state signal modified with the hedge signal in the step (b)." The Bozich patent generates no signal comparable to the reference model state signal which is generated with the commanded state signal modified with the hedge signal. Col. 13, Lines 29-35 of the Bozich patent merely discloses use of the controller with the value "ctgt" set to zero to cause the error signal to be the signal sensed by the sensor 39. Col. 18, Lines 49-67 of the Bozich patent discloses use of reference signals 42 compared at nodes 43a-43n with signals from sensors S1-Sn to generate error signals representing the difference between the sensed output vibration, and a desired reference vibration. The reference signals 42 of the Bozich patent are not shown or described to be generated by any other signal. Thus, step (c) of "generating a reference model state signal based on the commanded state signal modified with the hedge signal" necessarily could not be disclosed in the Bozich patent.

Claim 3 as amended recites the steps of "d) generating a tracking error signal based on the reference model state signal and a plant state signal; and e) generating an adaptive control signal **based on the tracking error signal** to adapt control response of the adaptive control system." Support for this amendment is found in Fig. 1 and corresponding description which discloses the adaptation law unit 26 generating an adaptive control signal based on the tracking error signal as well as Step S14 of Fig. 6 and corresponding description. No such tracking error signal is generated in the Bozich patent. In Col. 17, Lines 53-65 of the Bozich patent the weights used in the second neuro-controller 32M are set by error signals generated by subtracting the output of the sensor fusion circuit 94 and the input signals A01-A0N. However, these error signals are used to cause the adaptive control system of the Bozich patent to adapt to sensed error vibrations and to linearize the controlled dynamic device 34. Thus, because the effect of the a characteristic to which adaptation is not to occur is removed through use of the hedge signal, Claim 3 is patentable over the Bozich patent. Col. 19, Lines 41-49 of the Bozich patent discusses adapting to sound in order to damp it. In contrast, the effect of the hedged characteristic is removed from the tracking error signal of Claim 3 through the use of the hedge signal so that the adaptive control signal is generated in a way that is not impacted by the characteristic. Thus, Claim 3 is patentable over the prior art.

Claim 4 recites "wherein the hedge signal is generated in the step (a) based on a difference between a first signal derived from a plant model not having the characteristic, and a second signal derived from a plant model having the characteristic." The Bozich patent fails to disclose generating a hedge signal used to avoid adaptation to a characteristic, let alone one generated by the difference between signals derived from plant models having and not having the hedged characteristic. Col. 13, Lines 4-15 and 20-29 of the Bozich patent discuss the inverse neuro-emulator 36I and the summing node 37, both of which are used to adapt connection weights of the neuro-controller 32I. The neuro-controller 32I, inverse neuro-controller 36I and summing node 37 of the Bozich patent therefore adapt to damp error vibrations and linearize the controller 34. In contrast, the hedge signal is used to remove effects of characteristics to which the adaptive component of a control system is not to adapt. Therefore, Claim 4 is patentable over the prior art.

Claim 5 recites "wherein the first signal is generated based on an input control signal and a plant state signal in addition to the plant model not having the characteristic, and the second signal is generated further based on a command control signal and a plant state signal in addition to the plant model having the characteristic." The Bozich patent does not disclose generation of any such first and signal signals based on input control and plant state signals, and command control and plant state signals, as recited in Claim 5. As explained above, Col. 13, Lines 4-15 and 20-29 of the Bozich patent disclose a neuro-controller 32I, an inverse neuro-emulator 36I, and summing node 37 that are used to cause the adaptive control system of the Bozich patent to adapt to error vibrations and to linearize the controlled dynamic device 34. The adaptive control system of the Bozich patent thus does not generate first and second signals used to generated a hedge signal to remove effect of a characteristic to prevent adaptation so such characteristic as claimed. Thus, Claim 5 is patentable for this reason.

Claim 6 recites "wherein the input control signal is generated based on at least one of the commanded state signal, reference model state signal, a plant state signal, and an adaptive control signal." The Bozich patent discloses no such input control signal used in the generation of a hedge signal as recited in Claim 6. The inverse neuro-emulator 36I of col. 13, lines 16-19 of the Bozich patent adapts to error vibration and to linearize the controlled dynamic device 34.

The input control signal generated in Claim 6 is used in an entirely different way in generation of the hedge signal which prevents adaptation to the hedged characteristic.

Claim 7 recites "wherein the command control signal is generated based on the input control signal modified by a control allocation and a control characteristic imposed by the controller." The Bozich patent discloses no generation of any such command control signal in Col. 12, Lines 50-56 or elsewhere.

Claim 8 recites "wherein the second signal is generated based on an actuator state signal." The Bozich patent discloses no such actuator state signal. Col. 12, Lines 50-56 disclose an electronic shaker, but no state signal derived therefrom. Thus, Claim 8 is patentable over the prior art.

Claim 9 recites a step of "b) generating a display based on the input control signal, an operator generating the command control signal based on the display." The Bozich patent does not disclose generating a display based on the input control signal which is used by an operator to generate the command control signal based on the display. In Col. 5 Lines 5-20 the Bozich patent merely discloses display of a spoken word to a deaf person, and does not disclose anything comparable to generating a command control signal by such person. Accordingly, Claim 9 is patentable over the prior art.

Claim 10 recites that the plant is an aircraft and/or spacecraft. The Bozich patent mentions aircraft and spacecraft in its background section, but not in the context of generating a hedge signal as recited in Claim 1 to from which Claim 10 depends. Thus, Claim 10 is patentable over the prior art.

Claim 11 recites that the plant is an automobile. Col. 4, Lines 36-45 of the Bozich patent do not disclose use of any adaptive control system in an automobile. Thus, Claim 11 is patentable over the prior art.

Claim 12 recites that the plan is an unmanned vehicle. Col. 4, Lines 36-45 of the Bozich patent contain no mention of an unmanned vehicle. Thus, Claim 12 is patentable over the prior art.

Thus, for these reasons as well as for the reasons stated above with respect to Claim 1, Claims 2-12 are patentable over the prior art.

Claim 13 is restated for the Examiner's convenience below:

> 13. **(Original)** In an adaptive control system for controlling a plant, **a hedge unit** coupled to receive at least one control signal and a plant state signal, **the hedge unit generating a hedge signal based on the control signal, the plant state signal, and a hedge model including a first model having a characteristic to which the adaptive control system is not to adapt, and a second model not having the characteristic to which the adaptive control system is not to adapt, the hedge signal used in the adaptive control system to remove an effect of the characteristic from a signal supplied to an adaptation law unit of the adaptive control system so that the adaptive control system does not adapt to the characteristic in controlling the plant.**

The above-emphasized language of Claim 13 is not disclosed or even suggested in the Bozich patent. The Office action appears to assert that the hedge unit is the "offsetting vibration signal" of Fig. 3B; that the inverse neuro-emulator 36I of Col. 13, Lines 16-19 is the hedge model having the characteristic to which the adaptive control system is not to adapt; that the second model not having the characteristic is the output of the inverse emulator 36I compared with the input to the device 34 at summation point 35 in order to develop an inverse emulator error signal as described in Col. 13, Lines 4-15; and that the hedge signal is described in Col. 3, Lines 27-42. In the Bozich patent, the inverse neuro-emulator 36I, the neuro-controller 32I and the summing node 37 are all used to adapt to error vibrations in media 24 and to linearize the controlled dynamic device 34. Thus, the Bozich patent does not disclose any hedge unit as claimed in Claim 13, which generates a hedge signal to cause the adaptive control system not to adapt to a characteristic. Because of this fundamental difference, the Bozich patent necessarily could not disclose the details of Claim 13, such as the recited hedge model used to generate the hedge signal. Accordingly, Claim 13 is patentable over the prior art.

Claims 14-23 depend from Claim 13 and include all of the limitations of that Claim plus additional limitations that are not disclosed or even suggested by the prior art. For example,

Claim 14 recites "wherein the characteristic is a time delay between generation of the commanded state signal by the controller at a time, and receipt by the controller of the plant state signal resulting from the commanded state signal generated at the time." This feature is not disclosed in the Bozich patent. Col. 12, Lines 31-49 of the Bozich patent mention a time delay that is purposefully included in the system, and its effect necessarily impacts performance of the adaptive control system of the Bozich patent. In contrast, in Claim 14, the characteristic is a time delay to which adaptation is to be avoided by the adaptive control system through the use of the hedge unit. Thus, Claim 14 is patentable over the Bozich patent.

Claim 15 recites "wherein the characteristic is a time delay between generation of a state by the plant and sensing of the state of the plant by the sensor to generate the plant state signal." The time delay referenced in Col. 16, Lines 54-66 is purposefully included in the Bozich patent's system, and necessarily impacts performance of the adaptive control system of the Bozich patent. In contrast, the characteristic recited in Claim 15 is undesirable and adaptation to it is avoided through the use of the hedge unit. Thus, Claim 15 is patentable over the prior art.

Claim 16 recites "wherein the characteristic pertains to a control limit of the actuator used to control the plant." The Bozich patent fails to disclose this feature of the claimed invention. Col. 15, Lines 21-49 contains not mention of any control limit of an actuator. Thus, Claim 16 is patentable over the prior art.

Claim 17 recites "wherein the control limit pertains to actuator end points." The Bozich patent mentions nothing regarding actuator end points. Thus, Claim 17 is patentable over the prior art.

Claim 18 recites "wherein the control limit pertains to actuator dynamics." The Bozich patent contains no mention of a control limit, let alone one related to actuator dynamics. Thus, Claim 18 is patentable over the prior art.

Claim 19 recites "wherein the control limit pertains to a rate limit of the actuator." The Bozich patent has no mention of control limits, let alone one related to a rate limit of the actuator. Thus, Claim 19 is patentable over the prior art.

Claim 20 recites "wherein the control limit pertains to quantization effects associated with the actuator." The Bozich patent contains no mention of a control limit, let alone one

pertaining to quantization effects associated with an actuator. Thus, Claim 20 is patentable over the prior art.

Claim 21 recites "wherein the plant is an aircraft and/or spacecraft." Although the Bozich patent mentions "aircraft" or "spacecraft" it does not do so in the context of a hedge unit that generates a hedge signal to avoid adaptation to a characteristic of the system or plant for which adaptation is not desired to occur. Thus, Claim 21 is patentable over the prior art.

Claim 22 recites "wherein the plant is an automobile." Col. 4, Lines 36-45 of the Bozich patent contain no mention of any automobile, let alone in the context of a hedge unit used to hedge the effects of a characteristic to which adaptation is not desired. Accordingly, Claim 22 is patentable over the prior art.

Claim 23 recites "wherein the plant is an unmanned vehicle positioned remotely from an operator." Col. 4, Lines 36-45 of the Bozich patent has no mention of an unmanned vehicle, let alone in the context of a hedge unit used to hedge out the effect of a characteristic to which adaptation is not desired to occur. Therefore, Claim 23 is patentable over the prior art.

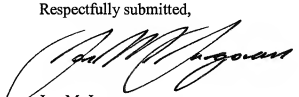
Thus, for these reasons as well as those stated above with respect to Claim 13, Claims 14-23 are patentable over the prior art of record.

Conclusion

It is submitted that Claims 1-23 are patentable over the prior art of record. It is therefore respectfully requested that a Notice of Allowance be issued. The Examiner is encouraged to contact Applicant's undersigned attorney at (404) 881-4583 to resolve any remaining issues in order to expedite examination of the present application.

It is not believed that extensions of time or fees for net addition of claims are required, beyond those that may otherwise be provided for in documents accompanying this paper. However, in the event that additional extensions of time are necessary to allow consideration of this paper, such extensions are hereby petitioned under 37 CFR § 1.136(a), and any fee required therefore (including fees for net addition of claims) is hereby authorized to be charged to Deposit Account No. 16-0605.

Respectfully submitted,



Jon M. Jurgovan
Registration No. 34,633

Customer No. 00826
ALSTON & BIRD LLP
Bank of America Plaza
101 South Tryon Street, Suite 4000
Charlotte, NC 28280-4000
Tel Atlanta Office (404) 881-7000
Fax Atlanta Office (404) 881-7777